# Hanford Site Environmental Monitoring Plan

# Section III.B. Groundwater Monitoring

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| Prepared by: Date:<br><br>P. D. Thorne, Pacific Northwest National Laboratory | Concurrence (RL): Date:<br><br>K. M. Thompson, U.S. Department of Energy, Richland Operations Office |

# Introduction

Groundwater monitoring is a critical element of the U.S. Department of Energy's (DOE's) environmental monitoring program at the Hanford Site because an unconfined aquifer and a system of deeper confined aquifers underlie the site. Groundwater from the unconfined aquifer entering the Columbia River is a significant pathway for transport of contaminants.

Groundwater monitoring is conducted at the Hanford Site for a variety of purposes: near-field monitoring of specific facilities, sitewide monitoring of existing contaminant plumes, and monitoring to assess the effectiveness of groundwater-remediation activities. Because the Hanford Site has multiple, extensive, and unique groundwater-pollution problems, DOE has established an integrated groundwater-monitoring project to ensure protection of the public and the environment while improving the efficiency of monitoring operations.

## Regulatory Drivers

The regulatory framework governing groundwater monitoring at the Hanford Site consists of integrated federal and state regulations, orders, and agreements. DOE Order 5400.1 establishes a groundwater-monitoring program that meets the requirements of DOE Order 5400.5, which deals with radiation protection of the public and the environment, and other applicable federal and state regulations. According to DOE Order 5400.1, groundwater-monitoring programs shall be conducted onsite and in the vicinity of DOE facilities for the following purposes:

- obtaining data for determining baseline conditions of groundwater quality and quantity
- demonstrating compliance with and implementation of all applicable regulations and DOE Orders
- providing data to permit the early detection of groundwater pollution or contamination
- identifying existing and potential groundwater-contamination sources and maintaining surveillance of these sources
- providing a reporting mechanism for detected groundwater pollution or contamination
- providing data on which decisions can be made concerning land-disposal practices and the management and protection of groundwater resources.

DOE Order 5400.1 also stipulates that, where applicable, groundwater monitoring around facilities be designed and implemented in accordance with regulations in Title 40, Code of Federal Regulations, Part 264 (40 CFR 264) or 265, Subpart F (pursuant to the *Resource Conservation and Recovery Act of 1976* [RCRA]). DOE Order 5820.2A, which deals with radioactive waste management, also requires groundwater monitoring; specifically, a system of groundwater- or vadose zone-monitoring wells meeting RCRA requirements (40 CFR 264) shall be installed, as a minimum, around clusters of liquid waste-storage tanks. DOE Order 5820.2A also stipulates that groundwater be monitored around low-level waste facilities.

RCRA establishes regulatory standards for the generation, transportation, storage, treatment, and disposal of hazardous waste and applies to active waste-management facilities and facilities undergoing closure. As authorized by the U.S. Environmental Protection Agency (EPA), State of Washington regulations Washington Administrative Code (WAC) 173-303 implement RCRA groundwater requirements in lieu of the federal regulations. WAC 173-304, which deals with solid waste, and WAC 173-216, which deals with permitted liquid discharges, also contain groundwater-protection and -monitoring requirements that apply to activities at the Hanford Site. RCRA corrective action requirements apply to inactive sites that have received RCRA permits. The *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) and the *Superfund Amendments and Reauthorization Act of 1986* (SARA), which are implemented through EPA regulations in 40 CFR 300, establish groundwater-monitoring requirements for other inactive "past-practice" waste sites. Under these laws, three areas of the Hanford Site (100, 200, and 300 Areas) are currently listed on the National Priorities List (40 CFR 300 Appendix B).

To coordinate the actions of various regulatory authorities and provide a strategy for achieving regulatory compliance and waste-site cleanup, the Hanford Federal Facility Agreement and Consent Order (also known as the Tri-Party Agreement) (Ecology et al. 1989) was established. This agreement between DOE, EPA, and the State of Washington Department of Ecology (Ecology) provides for the interface of overlapping regulatory programs. The agreement specifies that both active and inactive treatment, storage, or disposal (TSD) units that have received RCRA permits will be managed and closed under RCRA regulations, including groundwater-monitoring requirements. Other past-practice waste sites will be addressed under CERCLA regulations. Contaminated groundwater will be addressed as a CERCLA source of contamination. However, all CERCLA actions will meet RCRA corrective action standards under the agreement. In addition, CERCLA remedial actions at groundwater operable units designated as RCRA past-practice units will be incorporated into the Hanford Facility RCRA Permit (Ecology 1994). Under criteria established in the Tri-Party Agreement, a "lead regulatory agency" is designated for each operable unit to avoid inconsistency and duplication of effort.

## Project Management and Objectives

In the past, groundwater programs were independently developed to address the needs of various programs, including CERCLA, RCRA, WAC 173-216, operational monitoring, and sitewide environmental surveillance (DOE Order 5400.1). Because of increasing groundwater program overlap, regulatory complexity, and conflicting management issues, DOE recognized the need for a more effective, consistent, and objective project. Therefore, in 1996, DOE directed its contractors to integrate the various groundwater programs into one consolidated project. The Groundwater Monitoring Project is designed to address all groundwater-monitoring needs at the site, eliminate regulatory program redundancy, and establish a cost-effective hierarchy for groundwater-monitoring activities. Specific objectives of the Groundwater Monitoring Project are the following:

- maintaining and verifying compliance with all applicable groundwater regulations
- characterizing and defining hydrogeologic, physical, and chemical trends in the groundwater system
- establishing baselines of groundwater quality
- providing continuing, independent assessment of groundwater-remediation activities
- identifying and quantifying new or existing groundwater problems.

The Hanford Site groundwater-protection management plan (DOE/RL-89-12, Rev. 2) summarizes groundwater-protection policies, project-integration activities, program scope, and responsibilities. The

groundwater-protection management plan includes near-field monitoring at RCRA and other facilities, sitewide and offsite monitoring of groundwater-contaminant migration conducted under the environmental surveillance program, and monitoring conducted to support groundwater-remediation projects under CERCLA or RCRA corrective actions.

The Groundwater Monitoring Project is managed by Pacific Northwest National Laboratory (PNNL) in accordance with an established quality assurance plan, which conforms to the requirements of 10 CFR 830.120 as interpreted and implemented by the Standards-Based Management System (PNNL 1997).

Monitoring-well networks are located and constructed based on data quality objectives and/or criteria established in site-specific or regional monitoring plans. Groundwater monitoring at RCRA TSD units is conducted in accordance with site-specific groundwater-monitoring plans prepared and maintained by PNNL that conform to RCRA regulatory requirements. A project scientist is assigned to each site or logical grouping of sites and is responsible for ensuring execution of the plan. RCRA corrective action and CERCLA past-practice groundwater-monitoring requirements are documented in interim and final records of decision (RODs) and implementing plans. As required by DOE Orders, additional wells across the Hanford Site are sampled to monitor movement of existing contaminant plumes and to determine the impact of facilities not specifically addressed by other regulations. These wells comprise the sitewide environmental surveillance network.

## General Groundwater-Monitoring Information

This section provides general information for all Hanford Site groundwater-monitoring activities performed by the Groundwater Monitoring Project regardless of the specific purpose or regulatory driver. This is followed by sections with information that is applicable to RCRA groundwater monitoring, monitoring to support CERCLA and RCRA corrective actions, and sitewide environmental surveillance monitoring of groundwater.

### Construction and Maintenance of Wells

Both older wells and newer wells built to WAC 173-160 standards are used by the Groundwater Monitoring Project. Most older monitoring wells on the Hanford Site are 10, 15, or 20 cm in diameter and are constructed of carbon-steel casing. A number of newer wells are constructed of 10-cm stainless-steel casing. Most unconfined aquifer wells are completed with well screens or perforations in the upper 3 to 6 m of the aquifer.

For older existing wells, a fitness-for-use evaluation is conducted, and appropriate limitations are designated. Wells with limitations are sampled for a limited set of constituents or are used only for water-level measurements.

New wells are installed so as to maintain the integrity of the monitoring well borehole and prevent crosscontamination from the surface or other zones into the aquifer. The well casing isolates the sampled interval of the well from the vadose zone and nonsampled intervals of the aquifer. Screens are used to filter out solids and enhance collection of representative groundwater samples from the aquifer. All new wells meet the requirements of WAC 173-160. Groundwater-monitoring wells are located, designed, and constructed based on data quality objectives and criteria established in groundwater-monitoring plans.

Groundwater-monitoring wells require periodic maintenance to ensure that representative samples are obtained. Wells are typically scheduled for routine inspection and maintenance every 3 to 5 yr. Where a dedicated pump is installed, the pump is inspected and tested. A downhole video survey is then performed to verify integrity of the casing. The inside of the casing is usually brushed to remove deposits before replacing the pump. Nonroutine well maintenance may be scheduled when a problem is identified during sampling.

## Hydrologic Characterization and Modeling

Hydrologic characterization activities are conducted to gain understanding of hydrogeologic conditions and controls on groundwater and contaminant movement. Characterization activities include geologic sampling, geophysical logging of boreholes, and hydraulic and tracer testing of wells to determine aquifer-flow and -transport properties. These activities are directed toward developing site-specific and regional hydrogeologic models of the Hanford Site. A three-dimensional, multilayer, numerical, groundwater model of the unconfined aquifer has been constructed in conjunction with characterization. The model is used to predict the movement of groundwater and contaminants under present and future Hanford Site conditions. The model is also used to help determine impacts on the monitoring network and the best location for monitoring wells as Hanford Site activities and groundwater conditions change. Other modeling activities support groundwater-remediation and waste-management activities.

## Water-Level Monitoring

Water-level monitoring is performed to help characterize the direction and velocity of groundwater flow, to determine the impact of Hanford Site operations on the groundwater-flow system, and to assess the adequacy of point-of-compliance wells to detect groundwater impacts from specific monitored facilities. Routine water-level measurements in the unconfined aquifer are made annually to construct a sitewide water-table map and to determine flow directions in the vicinity of facilities that require groundwater monitoring. Water-table maps are published in the annual groundwater-monitoring report (e.g., PNNL-11470). The sitewide water-level information for the unconfined aquifer is used for the following:

- identification of recharge and discharge areas
- evaluation of physical influence of wastewater discharges on groundwater-flow directions
- determination of potential for water movement between adjacent groundwater and surface-water bodies
- determination of horizontal hydraulic gradient, which is needed to estimate the average linear velocity of groundwater flow and contaminant migration
- improvement of design of the water-level monitoring-well network
- maintenance of knowledge of groundwater-flow conditions at the site
- calibration of and verification of numerical groundwater-flow models.

The distribution of hydraulic head in the upper basalt-confined aquifer system is also monitored to assess the potential for contaminants to migrate off the Hanford Site through this aquifer and to evaluate the hydraulic relationship between the unconfined aquifer and upper basalt-confined aquifer systems.

In addition to the annual regional water-level measurements, site-specific measurements are also collected. The frequency of site-specific water-level measurements is determined by a variety of factors. Annual, semiannual, or quarterly monitoring is conducted for most wells. Near-continuous water-level monitoring is maintained in areas likely to experience rapid or significant changes in the water table. These areas are generally located near known recharge or discharge sources (e.g., waste-disposal facilities, public water-supply wells, and wells near the Columbia River). Water levels are measured routinely in wells before any groundwater sampling is performed.

## Groundwater Sampling and Analysis

Wells to be sampled each year by the Groundwater Monitoring Project will be documented in a separately published sampling schedule (i.e., PNNL-11464). The distribution of wells sampled during fiscal year 1996 is shown in Figures III.B-1 and III.B-2. This distribution is expected to change slightly from year to year, depending on changing groundwater conditions and project requirements.

Groundwater-sampling and associated quality control (QC) procedures are administered by PNNL through annual statements of work (SOWs) to other contractors. The SOWs specify wells to be sampled, analytes, sampling frequencies, quality requirements, analytical and sampling procedures, and reporting requirements. Analysis of groundwater samples is managed by Waste Management Federal Services of Hanford, Inc. through SOWs to commercial analytical laboratories. These SOWs specify analytical and QC procedures and reporting requirements pertaining to sample analysis.

The Groundwater Monitoring Project operates in accordance with a quality assurance plan that defines the controls, procedures, and documentation that are required. That plan implements the requirements of 10 CFR 830.120. Trained staff members collect samples according to written procedures. Samples are analyzed according to documented standard analytical procedures (e.g., SW-846). The quality of analytical data is verified by a continuing program of internal laboratory QC, which consists of participation in interlaboratory crosschecks, replicate sampling and analysis, submittal of blind standard samples and blanks, and splitting samples with other laboratories. Letters of instruction are prepared as needed to meet specific program requirements.

**Data Quality Objectives**. Data quality objectives are defined in the QC plan, an appendix of the quality assurance plan. As specified in the SOW for sampling and analysis, all groundwater monitoring is covered by the same set of quality procedures.

Five basic data quality criteria are applied: precision, accuracy, representativeness, completeness, and comparability, along with applicable project-specific quality parameters to evaluate the data and the laboratories analyzing the samples. Evaluation of the sampling and analysis results with respect to the five basic data quality criteria are summarized below.

- Precision is evaluated using data results from laboratory duplicates, matrix spike duplicates, field duplicates, and blind samples.

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**Figure III.B-1**. Unconfined Aquifer-Monitoring Wells Sampled in Fiscal Year 1996

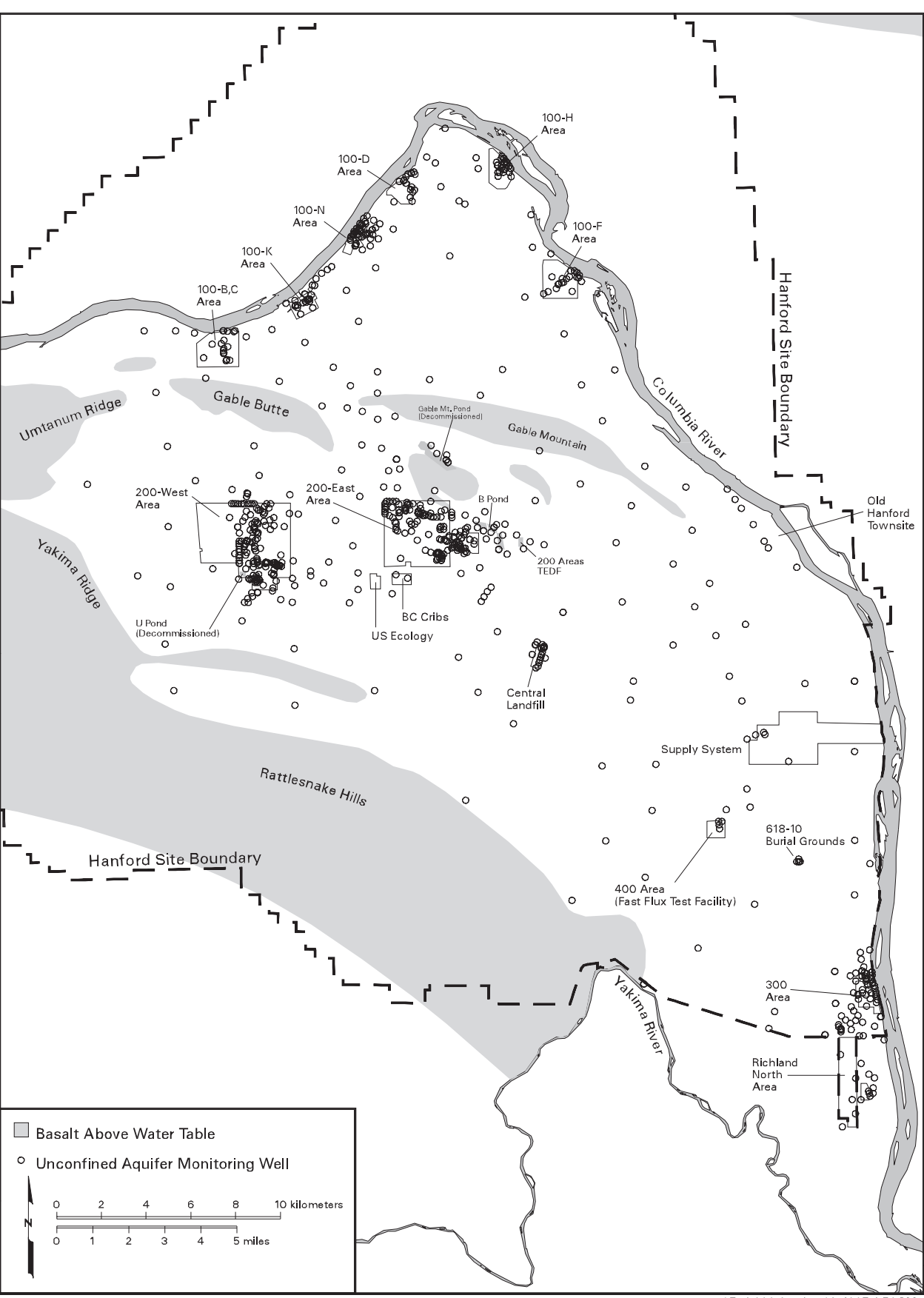


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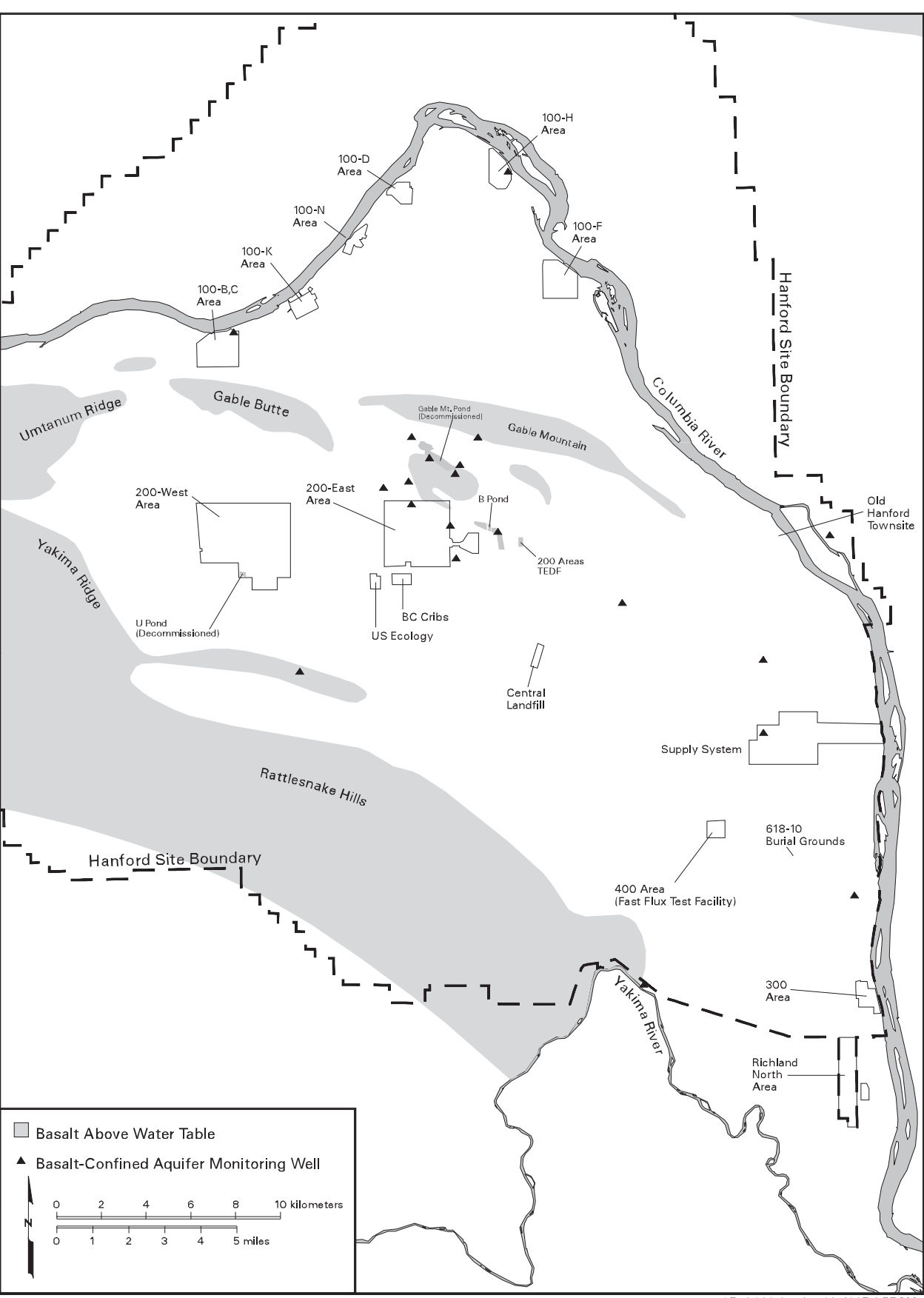
**Figure III.B-2**. Basalt-Confined Aquifer-Monitoring Wells Sampled in Fiscal Year 1996

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- Accuracy is evaluated using data results from laboratory matrix spikes; laboratory control samples; EPA water-pollution, water-supply, and interlaboratory-performance-evaluation programs; and blind samples.

- Representativeness expresses the degree to which facility groundwater-monitoring data represent the real composition of the groundwater in the aquifer. Goals for data representativeness for groundwater-monitoring programs are addressed qualitatively by the specification of well construction, sampling locations, sampling intervals, and sampling and analysis techniques identified in the groundwater-monitoring plan for each RCRA facility.

- Completeness is defined as the percentage of measurements made that are judged to be valid. Completeness is determined by the number of data not flagged as invalid divided by the total number of data validated multiplied by 100. The calculated percentages used in reporting completeness are conservative figures and are based on data flags. For each method, the percent complete each quarter should be at least 90%.

- Comparability is used to ensure that samples analyzed by different laboratories or by the same laboratory over different time periods are comparable. Samples are analyzed in accordance with SW-846 and other applicable approved methods. Comparability of field measurements is determined by following approved sampling procedures that ensure consistency among sampling events.

Limits for reporting, precision, accuracy, and completeness are presented in the QC plan. Site-specific groundwater-monitoring or -assessment plans specify whether a particular site has more stringent data quality objectives than those specified in the QC plan.

Objectives for precision and accuracy for chemical analyses are based on criteria stipulated in the methodology (e.g., SW-846, EPA-600/4-79-020). Guidelines for precision and accuracy for chemical QC data are provided in the QC plan.

Detection limits for chemical and radiological constituents are defined in the laboratory contract. For radiological constituents, reporting limits as low as 1/3 the derived 4-mrem 1-yr effective dose equivalent are preferred but are not always achievable. Preferred reporting limits and actual reporting limits for radiological constituents are listed in the QC plan. For chemical constituents, detection limits as low as 1/3 of the EPA primary drinking water standards are preferred. In some cases, detection limits that are 1/3 of drinking water standards are not feasible (e.g., pentachlorophenol and cadmium). Because detection limits change frequently, these values are not provided in the QC plan.

**QC Program**. The QC program helps to ensure the reliability and validity of field and laboratory measurements conducted in support of the Groundwater Monitoring Project. QC practices are defined in the QC plan for the project. Field and laboratory QC components and reporting requirements are included in the plan. Laboratory QC includes analysis of method blanks, matrix spikes, matrix duplicates, matrix spike duplicates, surrogate spikes, and laboratory-control samples. Blind standards are also forwarded to the laboratory each quarter. The results from field and laboratory QC samples are evaluated to determine whether the contracted laboratories are performing satisfactorily.

## Data Management and Interpretation

Groundwater data are managed using computer databases and hard-copy files. Water-level and analytical data are currently stored in the Hanford Environmental Information System (HEIS) computer database. Well

logs, effluent data, hydraulic parameters, field/sampling records, hard-copy analytical results, and other related information are assembled and stored in project files by the contractors responsible for the work.

Data from wells that monitor waste-disposal facilities are reviewed for compliance with applicable internal guidelines and state and federal regulations. If monitoring indicates that a facility is out of compliance, or that groundwater is being impacted, an investigation is initiated to determine the causes and evaluate remedial actions. The details of these types of investigations are discussed in later sections on facility-specific monitoring.

Interpretation activities include observing trends in contaminant concentrations of individual wells, mapping contaminant plumes, determining groundwater-flow directions, computing aquifer properties such as hydraulic conductivity, compiling effluent-source information, and modeling the groundwater system to make predictions. Interpretation results are documented in the annual groundwater-monitoring report (e.g., PNNL-11470) and in other topical reports.

### Groundwater-Monitoring Reports

All Hanford Site groundwater-monitoring activities are summarized in a comprehensive annual groundwater-monitoring report (e.g., PNNL-11470). That report discusses groundwater-chemistry results and suspected sources of groundwater contaminants. Maps are provided for most of the groundwater-contaminant plumes. Water-table maps for the unconfined and upper basalt-confined aquifer systems and a discussion of site hydrogeology are also provided. Data are tabulated and included in an electronic format. A summary description of the QC program for sample analysis and a summary of the fiscal year's activities, together with the required statistical evaluations, are appended to the report.

Results of operational and RCRA TSD monitoring are also included in the groundwater annual report. RCRA regulations require that measured constituent concentrations and any changes in parameters for each groundwater-monitoring well must be reported. Any significant differences from the initial background levels found in the upgradient well(s) are separately identified in the annual report (e.g., PNNL-11470). In addition to the annual report, quarterly RCRA letter reports, summarizing major findings for that quarter, are prepared and submitted to Ecology. A list of the quarterly reports is included in each annual report for the respective report year. The quarterly reports consist of regulatory notification letters that indicate that the data have been validated and made available electronically. The annual report provides an interpretive analysis of all the available data. For assessment-level RCRA monitoring, a report of the results of the groundwater quality assessment program must be submitted annually. This may be included in the annual groundwater report or issued as a separate report.

The annual report (e.g., PNNL-11470) also summarizes groundwater-monitoring activities at the Solid Waste Landfill as required by WAC 173-304. Special project reports are issued periodically that include groundwater impact assessments (e.g., WHC-SD-EN-EV-008), data evaluation reports, journal articles, and presentations.

## RCRA and Operational Groundwater Monitoring

The primary purposes of RCRA and operational groundwater monitoring are 1) to comply with the intent of state and federal RCRA requirements, 2) to assess potential impact on groundwater quality, and 3) to provide an early warning of unexpected occurrences and trends. Ecology and EPA issued the

Hanford Facility RCRA Part B Permit in September 1994 (Ecology 1994). In the permit, Ecology and EPA designated the Hanford Site as a single RCRA facility with over 60 individual liquid and solid waste TSD units. The Tri-Party Agreement (Ecology et al. 1989) recognized that all of the TSD units cannot be permitted simultaneously and set up a schedule for submitting unit-specific Part B RCRA/dangerous waste permit applications and closure plans to Ecology and EPA. Of the 60 TSD units, 26 require groundwater monitoring to determine if operations are impacting the uppermost aquifer. The locations of these RCRA TSD units are shown in Figure III.B-3.

RCRA groundwater-monitoring requirements fall under one of two categories: interim status or final status. A permitted (Part B) or closed RCRA TSD unit requires final-status groundwater monitoring as specified in 40 CFR 264 and WAC 173-303-645. RCRA TSD units without completed Part B permits or closure plans require interim-status groundwater monitoring as specified in 40 CFR 265 and WAC 173-303-400. Table III.B-1 lists the RCRA facilities requiring groundwater monitoring and the status of the each unit as of October 1, 1997.

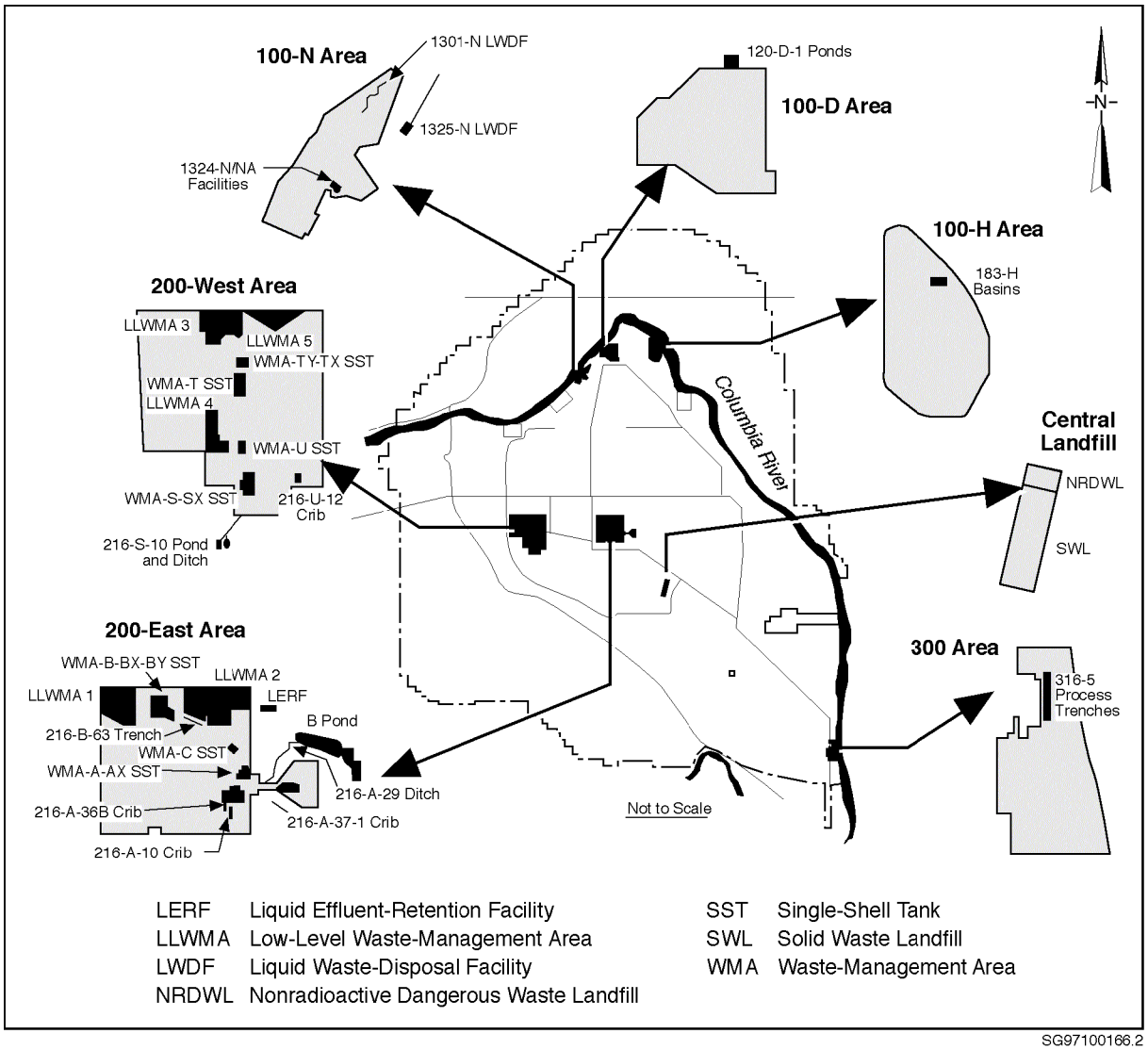


**Figure III.B-3**. Hanford Site RCRA Facilities Requiring Groundwater Monitoring

**Table III.B-1**. Hanford Site Interim- and Final-Status Groundwater-Monitoring Projects (as of October 1, 1997)

| | Interim-Status TSD Unit Groundwater Monitoring | | Final-Status TSD Unit Groundwater Monitoring | | | |
|---|---|---|---|---|---|---|
| TSD Unit, Date Initiated | Indicator Parameter Evaluation[a] | Groundwater Quality Assessment, Date Initiated | Detection Evaluation | Compliance Evaluation | Associated (CERCLA) Groundwater Operable Units | Year Scheduled for Part B or Closure |
| 120-D-1 Ponds, April 1992 | X | | | | 100-HR-3 | 1998[b] |
| 183-H Solar Evaporation Basins, June 1985 | | | | X | 100-HR-3 | 1994[b] |
| 1301-N LWDF, December 1987 | X | | | | 100-NR-2 | 1999[b] |
| 1324-N/NA Pond, December 1987 | X | | | | 100-NR-2 | 1998[b] |
| 1325-N LWDF, December 1987 | X | | | | 100-NR-2 | 1999[b] |
| 216-B-3 Pond, November 1988 | X | | | | 200-PO-1 | 2000[b] |
| 216-A-29 Ditch, November 1988 | X | | | | 200-PO-1 | 2000[b] |
| 216-A-10 Crib,[c] November 1988 | X | X, 1997 | | | 200-PO-1 | >2000[b] |
| 216-A-36B Crib,[c] May 1988 | X | X, 1997 | | | 200-PO-1 | >2000[b] |
| 216-A-37-1 Crib,[c] 1997 | | X, 1997 | | | 200-PO-1 | >2000[b] |
| 216-B-63 Trench, August 1991 | X | | | | 200-PO-1 | 2000[b] |
| 216-S-10 Pond, August 1991 | X | | | | | >2000[b] |
| 216-U-12 Crib, September 1991 | | X, 1993 | | | 200-UP-1 | >2000[b] |
| LERF, July 1991 | X | | | | | 1997[d] |
| LLBG WMA-1, September 1988 | X | | | | | 1997[d] |
| LLBG WMA-2, September 1988 | X | | | | | 1997[d] |
| LLBG WMA-3, October 1988 | X | | | | | 1997[d] |
| LLBG WMA-4, October 1988 | X | | | | 200-ZP-1 | 1997[d] |
| LLBG WMA-5, March 1992 | Discontinued in 1995 | | | | | 1997[d] |

**Table III.B-1**. (contd)

| TSD Unit, Date Initiated | Interim-Status TSD Unit Groundwater Monitoring | | Final-Status TSD Unit Groundwater Monitoring | | Associated (CERCLA) Groundwater Operable Units | Year Scheduled for Part B or Closure |
|---|---|---|---|---|---|---|
| | Indicator Parameter Evaluation[a] | Groundwater Quality Assessment, Date Initiated | Detection Evaluation | Compliance Evaluation | | |
| WMA-A-AX SST, February 1990 | X | | | | | >2000[b] |
| WMA-B-BX-BY SST, February 1990 | | X, 1996 | | | | >2000[b] |
| WMA-C SST, February 1990 | X | | | | 200-PO-1 | >2000[b] |
| WMA-S-SX SST, October 1991 | | X, 1995 | | | 200-UP-1 | >2000[b] |
| WMA-T SST, February 1990 | | X, 1993 | | | 200-ZP-1 | >2000[b] |
| WMA-TX-TY SST, September-October 1991 | | X, 1993 | | | 200-ZP-1 | >2000[b] |
| WMA-U SST, October 1990 | X | | | | 200-ZP-1 | >2000[b] |
| 316-5 Area Process Trenches[e], June 1985 | | X | | X (1996 to final status) | 300-FF-5 | 1996[b] |
| NRDWL, October 1986 | X | | | | 200-PO-1 | >2000[b] |

(a) Specific parameters (pH, specific conductance, total organic carbon, and total organic halogen) used to determine if a facility is affecting groundwater quality. Exceeding the established limits means that additional evaluation and sampling are required (groundwater quality assessment). An X in the column indicates whether an evaluation was needed or an assessment was required.
(b) Closure/postclosure plan; TSD unit will close under final status.
(c) 216-A-10, 216-A-36B, and 216-A-37-1 Cribs will be combined in fiscal year 1997 into one RCRA monitoring unit. RCRA monitoring will be performed according to interim-status groundwater quality assessment requirements.
(d) Part B permit; TSD unit will operate under final-status regulations beginning in year indicated.
(e) At the end of calendar year 1996, these will move from an interim-status assessment-monitoring evaluation (required by regulatory consent agreement and compliance order [Ecology and EPA 1986]) to a final-status compliance-monitoring evaluation.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*.
LERF = liquid effluent retention facility.
LLBG = low-level burial ground.
LWDF = liquid waste-disposal facility.
NRDWL = Nonradioactive Dangerous Waste Landfill.
RCRA = *Resource Conservation and Recovery Act of 1976*.
SST = single-shell tanks.
TSD = treatment, storage, or disposal.
WMA = waste-management area.
> = Beyond the year 2000.

In addition to RCRA facilities, there are non-RCRA operational facilities on the Hanford Site that are regulated under the requirements of DOE Orders, State of Washington regulations, and the Tri-Party Agreement. Many of these are disposal facilities that receive treated effluents derived from liquid wastes associated with nuclear material processing, refining, and waste-treatment activities. All major discharges of untreated wastewater were terminated in June 1995. In December 1991, an agreement was reached to include all miscellaneous waste streams and/or any new waste-stream discharges to the ground under the waste-discharge permit system defined in WAC 173-216. Groundwater monitoring is conducted at three of these sites: 400 Area Process Pond, 200 Areas Treated Effluent Disposal Facility, and 200 Areas Effluent Treatment Facility disposal site. The Solid Waste Landfill is another non-RCRA facility that requires groundwater monitoring. This disposal facility is not addressed under the Tri-Party Agreement. Current operations and groundwater-monitoring activities conducted at the Solid Waste Landfill are regulated by WAC 173-304-490. Current groundwater-monitoring plans for these four facilities will be referenced in the annual groundwater-monitoring report (e.g., PNNL-11470).

## RCRA Interim Status

Interim-status RCRA facilities are monitored under one of three phases: background monitoring phase, indicator parameter-evaluation phase, or groundwater quality assessment phase. A groundwater-monitoring plan for each RCRA facility describes the monitoring network, sampling and analysis procedures, analytes, and sampling frequency.

As specified in 40 CFR 265, groundwater samples from all RCRA monitoring wells must be obtained and analyzed quarterly for 1 yr to establish background concentrations for future data comparisons. Site-specific analytes (including radionuclides) are determined from evaluation of the waste stream or source associated with the facility. Additional site-specific constituents may be included to aid in tracking groundwater movement and the influence of other facilities. In some cases, the list of constituents from 40 CFR 264 Appendix IX is analyzed to establish a baseline for future comparisons. All of the RCRA facilities have completed their initial background monitoring phases.

After background levels of groundwater constituents are established, the indicator parameter-evaluation program commences. Samples are collected semiannually to determine whether groundwater contamination from the facility is present. Sample data are compared with background data for selected indicator parameters. If a statistically significant change over background has occurred in a downgradient well, Ecology must be notified and a groundwater quality assessment-monitoring plan must be prepared and implemented. That plan defines steps to be taken to determine if the facility is the contaminant source and, if so, to determine the magnitude and extent of the contamination. RCRA facilities under the groundwater quality assessment phase may require an expanded groundwater-monitoring network and be monitored quarterly. Ecology may require corrective action through an administrative order if the results of the assessment indicate significant hazards to human health and the environment.

To determine whether a statistically significant change has occurred, the sample results from upgradient wells during the first year of monitoring are averaged, and summary statistics (mean, standard deviation, and coefficient of variation) are developed for each RCRA facility. Once the background summary statistics have been developed, the averaged-replicate t-test (OSWER-9950.1) is used to calculate the test statistic for each contaminant indicator parameter. The test statistic is reformulated in such a way that a critical mean can be obtained for each indicator parameter. These critical means have been adjusted to control the overall facility false-positive rate at 1%, which is consistent with the performance standard required for RCRA facilities operated under interim status (40 CFR 265.93[b]).

## RCRA Final Status

Site-specific groundwater-monitoring requirements (e.g., well networks, analyte lists) for final-status RCRA facilities are negotiated and included in the Hanford Facility RCRA Permit (Ecology 1994). These requirements are incorporated into the permit as site-specific groundwater-monitoring plans, which are prepared according to the permit-modification schedule. Facilities currently conducting final-status groundwater monitoring and the date that current interim-status facilities are scheduled to become final status were listed in Table III.B-1.

Three phases of groundwater monitoring are specified under final-status regulations: detection monitoring, compliance monitoring, and corrective action.

In a detection-monitoring program, groundwater-sampling results from downgradient wells for parameters listed in the unit-specific groundwater-monitoring plan are compared with those from background wells to determine whether there has been a statistically significant change from background concentrations. Statistical methods appropriate for a final-status detection-monitoring program include analysis of variance, tolerance intervals, prediction intervals, control charts, test of proportions, or other statistical methods approved by Ecology. The distribution(s) of monitoring parameters; the nature of the data; the proportions of nondetections; and seasonal, temporal, and spatial variations are important factors to consider when selecting appropriate statistical methods. The statistical evaluation procedures chosen are based on PB89-151047, EPA/530-R-93-003, Gibbons (1992), and ASTM (1996). Specifics are addressed in the unit-specific permit applications.

A compliance groundwater-monitoring program is established if detection monitoring reveals a statistically significant change in an indicator parameter. The objective of compliance-level monitoring is to determine if the monitored facility is in compliance with groundwater-protection standards. This is accomplished by comparing the concentrations of constituents of concern to groundwater-protection standards such as the risk-based maximum concentration limit; an alternate concentration limit; natural background; or applicable, relevant, and appropriate requirements.

Maximum concentration limits are identified for each of the groundwater-monitoring parameters listed in Table 1 of WAC 173-303-645. Alternate concentration limits may be proposed after considering the observed concentrations of chemical constituents in the groundwater that might originate from the regulated unit in question. The area background, natural background, and other standards and requirements that are applicable, relevant, and appropriate are evaluated when proposing an alternate concentration limit.

If, during compliance-level monitoring, the referenced concentration limit(s) for a given groundwater parameter(s) is significantly exceeded, a corrective action program is developed and implemented to protect human health and the environment. Details for the corrective action program are specified in the unit-specific permit applications or closure plans. Additionally, a groundwater-monitoring plan used to assess the effectiveness of the corrective action measures is submitted. That monitoring plan is similar in scope to the compliance-level groundwater-monitoring program and includes all relevant information pertaining to the location and description of monitoring wells, monitoring network, well construction and development, sampling and analysis plans, statistical methods, and quality procedures.

Under final-status regulations, all wells at each TSD unit must be sampled at least semiannually. Two sampling procedures are allowed: a sequence of at least four samples is taken over a time interval that ensures, to the greatest extent technically feasible (default sampling procedure), that an independent sample is

obtained or an alternate sampling procedure approved by the regulator(s) that is protective of human health and the environment (40 CFR 264.97, WAC 173-303-645). Specific sampling frequencies and statistical evaluation methods are provided in the unit-specific groundwater-monitoring plan.

## CERCLA Past-Practice/RCRA Corrective Action Groundwater Monitoring

Groundwater monitoring is conducted to support the CERCLA past-practice and RCRA corrective action characterization and remediation activities at inactive sites. For the purpose of conducting these activities, the waste sites (called past-practice sites) and associated contaminated groundwater have been grouped into operable units (OUs). There are 63 source (waste site), 10 groundwater, and 1 combined source/groundwater OUs. Groundwater OUs are linked to numerous source OUs, which may have contributed to regional plumes of contamination but are treated separately from the source units for remediation. The locations of the groundwater OUs are shown on Figure III.B-4.

The OUs are designated as either RCRA past-practice units or CERCLA past-practice units. This designation ensures that only one past-practice program is applied to each OU. The same groundwater-monitoring activities are conducted at the OUs regardless of the applicable regulatory past-practice program.

Characterization-phase monitoring is performed to support decisions leading to a ROD or permit modification for the OU. Surveillance-phase monitoring is conducted to meet the objectives of the final ROD or permit modification issued for the OU. One OU (1100-EM-1) has received a final ROD (ROD 1993), which requires surveillance-phase monitoring. Maintenance-phase monitoring is conducted at OUs where characterization monitoring has been completed but the ROD or permit modification has not yet been issued. Maintenance-phase monitoring is also conducted at sites where an interim ROD or expedited response action is in effect. As of September 1997, characterization monitoring is complete but RODs or permit modifications have not been issued for OUs 100-BC-5, 100-FR-3, 200-BP-5, and 200-PO-1. Requirements for maintenance-phase monitoring at these sites is specified in letters to Ecology that are part of the administrative record. OUs where an interim ROD has been issued include 200-UP-1 (ROD 1997), 200-ZP-1 (ROD 1995), 300-FF-5 (ROD 1996a), 100-HR-3 and 100-KR-4 (ROD 1996b). An expedited response action is being conducted at OU 100-NR-2 (ERA 1994). Characterization-, maintenance-, and surveillance-phase monitoring conducted at these sites also meet the objectives of DOE Order 5400.1.

Additional groundwater monitoring is conducted outside of but consistent with this *Environmental Monitoring Plan*. This type of monitoring is focused strictly on evaluating the performance of groundwater-remediation activities at an expedited response action site (e.g., 100-NR-2) and at interim ROD sites (e.g., 100-HR-3, 100-KR-4, 200-UP-1, and 200-ZP-1).

A listing of the groundwater OUs, the regulatory classification, the current status of each relative to ROD/RCRA permit modification, and the general category of environmental monitoring is given in Table III.B-2. The sampling schedules and constituent lists for all groundwater OUs will be published in a separate annual sampling schedule (e.g., PNNL-11464) and the results will be reported in the annual report (e.g., PNNL-11470).

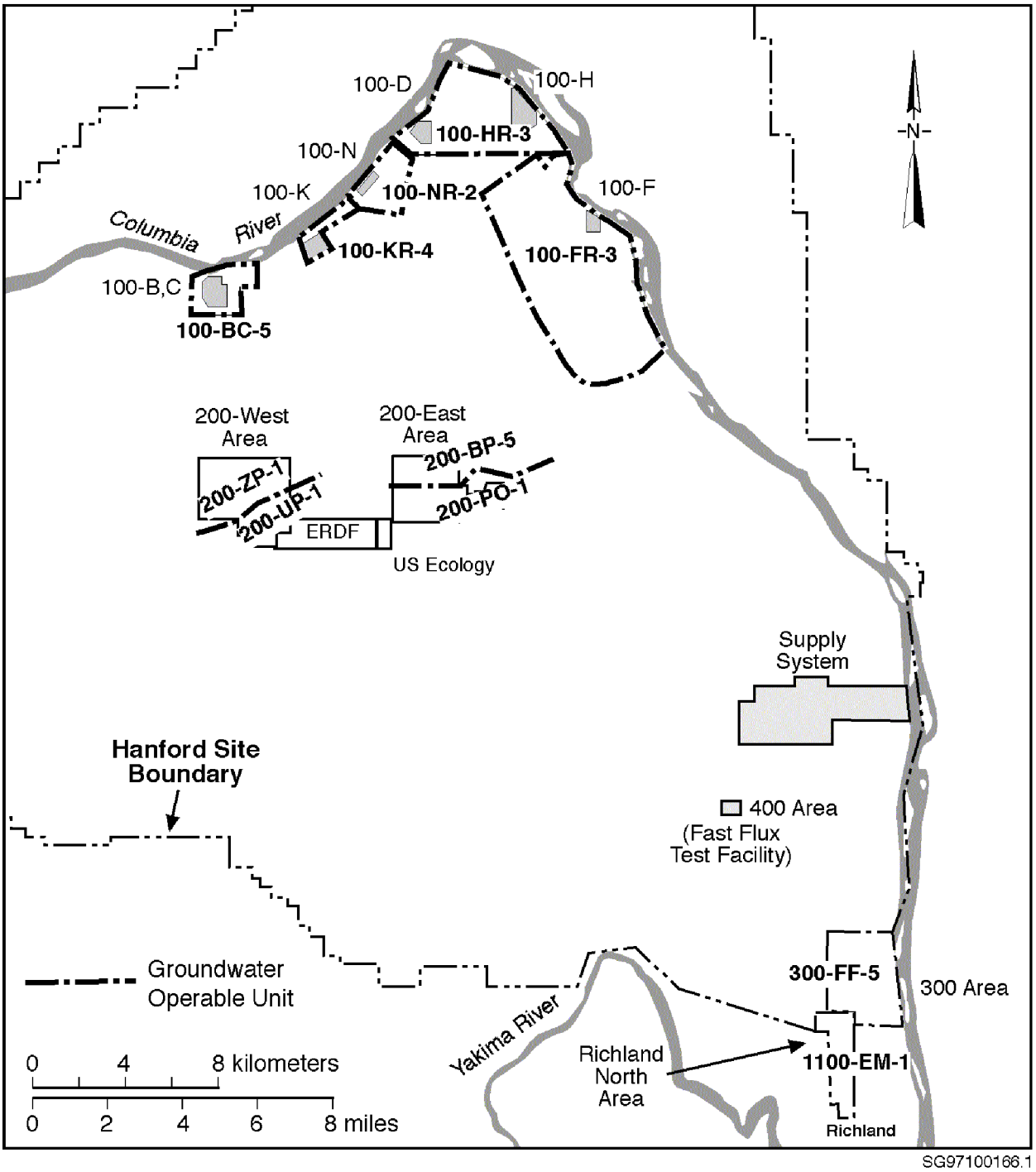


**Figure III.B-4**. Groundwater Operable Units on the Hanford Site

**Table III.B-2**. Groundwater Operable Unit Summary - Environmental Monitoring

| Operable Unit Designation | Regulatory Program Classification | Status Relative to ROD/RCRA Permit | Monitoring Category |
|---|---|---|---|
| 1100-EM-1 (Groundwater and Source Operable Unit) | CPP | Post-ROD | Surveillance |
| 300-FF-5 | CPP | Interim ROD | Maintenance |
| 100-BC-5 | CPP | Pre-ROD | Maintenance |
| 100-FR-3 | CPP | Pre-ROD | Maintenance |
| 100-HR-3 | CPP | Interim ROD | Maintenance |
| 100-KR-4 | CPP | Interim ROD | Maintenance |
| 100-NR-2 | RPP | Pre-Permit & ERA | Maintenance |
| 200-BP-5 | CPP | Pre-ROD | Maintenance |
| 200-PO-1 | RPP | Pre-Permit | Maintenance |
| 200-UP-1 | CPP | Interim ROD | Maintenance |
| 200-ZP-1 | CPP | Interim ROD | Maintenance |

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*.
CPP = CERCLA past-practice.
ERA = expedited response action.
RCRA = *Resource Conservation and Recovery Act of 1976*.
ROD = record of decision.
RPP = RCRA past-practice.

## Sitewide Environmental Surveillance of Groundwater

Additional sitewide monitoring of groundwater is required to meet the environmental surveillance program objectives stated in DOE Order 5400.1 and described in DOE/EH-0173T. The primary objectives addressed by sitewide groundwater monitoring are the following:

- evaluation of existing and potential offsite impacts of groundwater contaminants from the Hanford Site
- providing an integrated assessment of groundwater quality
- characterizing and defining hydrogeologic, physical, and chemical trends in the sitewide groundwater system
- establishing baselines of groundwater quality
- assessing existing and emerging groundwater quality problems.

The movement of existing widespread contaminant plumes is tracked, and flow-system characterization and modeling are conducted to predict future plume movement. These activities allow actual and potential

impacts to offsite water users to be evaluated. This section identifies the rationale and design criteria for sitewide monitoring of radiological and chemical contaminants in groundwater.

Data from operational and compliance monitoring (e.g., RCRA, CERCLA) of groundwater near specific facilities are integrated with information from the sitewide monitoring network. Data from wells that supply water to the Fast Flux Test Facility water system are also used in the sitewide interpretation. The sitewide monitoring network is designed to supplement these data to meet the objectives listed above. Additional wells selected for sampling each year generally fall into the following categories:

- contaminant source areas - Source areas include regions with active waste-disposal facilities or with facilities that have generated or received waste in the past. These data are generally provided by facility-specific monitoring networks. However, additional wells may be identified to characterize contaminant sources and to supplement operational monitoring networks.

- known contaminant plumes - Wells located within known contaminant plumes are monitored to characterize and define trends in the concentrations of radiological or chemical constituents. These wells are also monitored to meet the objective to quantify existing groundwater quality problems and to provide a baseline of environmental conditions against which future changes can be assessed.

- near water supplies - Water-supply wells on and near the site potentially provide a route for human exposure to contaminants in groundwater. Three water supplies exist onsite: Fast Flux Test Facility, Yakima Barricade guardhouse, and Hanford Patrol academy. Water-supply wells for the City of Richland are adjacent to the southern boundary of the Hanford Site. Wells near these water supplies and, in some cases, the water-supply wells themselves, are monitored to identify potential water quality impacts.

- Hanford Site perimeter - Wells along the Hanford Site perimeter are monitored to assess the quality of groundwater as it leaves the site. Wells along the northern, eastern, and southern boundaries of the site have been identified. Data from these wells help address objectives, including evaluation of existing and potential offsite impacts of groundwater contaminants, establishment of baselines of groundwater quality, and assessment of existing and emerging groundwater quality problems.

- offsite - Groundwater is utilized as a source for domestic and agricultural water outside the Hanford Site. Offsite wells may be monitored periodically to ensure that contaminants from Hanford Site sources are not present and to maintain a baseline of information on offsite water quality.

- background areas - Wells in areas upgradient from Hanford Site operations are sampled to provide information on background groundwater quality. These data are needed to assess the impact of site operations on groundwater and also to identify contaminants contributed by offsite upgradient sources.

Wells planned for sampling and constituents to be analyzed during each fiscal year will be published in a separate sampling schedule (e.g., PNNL-11464). Results of sitewide groundwater monitoring are discussed in the annual groundwater report (e.g., PNNL-11470). Figure III.B-1 showed the distribution of wells sampled during fiscal year 1996 for the unconfined aquifer system. Wells completed in the upper basalt-confined aquifer system are sampled to monitor groundwater conditions and the movement of contaminants found in this aquifer near the 200 Areas. Basalt-confined aquifer wells near the perimeter of the site are also monitored periodically. Wells completed in the basalt-confined aquifer and

sampled during fiscal year 1996 were identified in Figure III.B-2. The monitoring well network may change from year to year based on groundwater-flow conditions, movement of contaminant plumes, and project objectives.

Analytes for the sitewide monitoring network wells are selected based on the constituents present in nearby plumes and the inventories of potential groundwater contaminants at upgradient sources. Sampling frequencies vary from monthly to less than annually based on observed plume movements and expected changes in constituent concentrations. The analytes selected for each well will be listed in the sampling schedule and results will be presented in the annual groundwater report.

## Exceptions

No exceptions have been taken to *should** statements in DOE/EH-0173T.

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